Title

Muffler and Catalytic Converter Devices

Cross Reference

This application claims priority from the following Chinese patent applications: "Dissipative Automobile Exhaust Mufflers" filed on "April 24, 2003", having a Chinese Application No. 03114334.2; and " Automobile Exhaust Catalytic Converter Devices", filed on "April 30, 2003", and having a Chinese Application No.: 03114399.7; and "Automobile Exhaust Muffler and Purifying Devices, filed on "December 26, 2003", and having a Chinese Application No.:200320125349.5. All of the above applications are incorporated here by reference.

Field of Invention

This invention relates to muffler devices, catalytic converter devices, and combination muffler catalytic converter devices for the exhaust system of an engine. More particularly, it relates to the use of porous metal as the sound absorption material and the substrate for the catalyst for muffler devices, catalytic converter devices, and combination muffler catalytic converter devices for the exhaust system of engines.

Background

The removal of environmental contaminants from an engine's exhaust and the muffling of engine noise are all integral functions of the exhaust system of an engine. At present, for machines operated by engines such as automobiles, two separate devices perform

these functions. The muffler is used to reduce engine noise while the catalytic converter is used to purify the exhaust by the removal of environmentally harmful contaminants. Having two separate devices to perform these two functions not only causes a decrease in engine efficiency, it also increases the cost of production of the exhaust system by the increase in the cost of the production and installation of the two devices.

Catalytic converters often use ceramic and metal as the substrate for the catalyst. Honeycombed ceramic substrates have many disadvantages when compared with metal substrates. They generally operate at lower temperatures since ceramic softens at about 1400°C. Their walls are thicker. They preheat slower and the exhaust pressure in systems with these catalytic converters is higher. For these reasons, many countries are conducting research on the use of metal substrates. The wall of a metal substrate is only a quarter as thick as that of the ceramic substrate. As a result, exhaust pressure is lowered and the substrate for the catalyst can be made smaller. Metal substrates can be heated efficiently since they have a small capacity and can be electrically preheated. Moreover, metal substrates can adapt well to temperature changes.

Existing metal substrates of automobile exhaust catalytic converter mainly use combinations of various structures of corrugated metal. Their resistance to heat and mechanical impact are low. At high temperatures, their anti-oxidation ability is insufficient, thereby affecting life of the devices. In addition, the specific surface area of these corrugated metal substrate are limited and their capacity for the catalyst to be adsorbed is inadequate, limiting the efficiency of these devices.

At present, automobile exhaust muffler system customarily use reactive type mufflers because these systems are constructed of metal with simple structures that are durable and can

withstand high temperature, corrosion, and impact from the flow of exhaust. However, the spectrum of sound absorption for the reactive type muffler is narrow with sound absorption better at low frequencies and worse at high frequencies. In order to compensate for the weakness in high frequency sound absorption, multi-stage combinations structures such as, multi-stage mufflers or dissipative and reactive combination mufflers are often used to achieve better results. These devices are complex and increase the cost for the production of mufflers.

Alumina felt and asbestos felt are commonly used materials for sound absorption. They can resist high temperature and corrosion and can be firmly secured to a surface protecting structure. However, they are not durable as their ability to resist impact, humidity, and dust is low. Their sound absorption capability is also insufficient. Therefore, at present, they are not widely used in the automobile industry.

Due to the limitations of the prior art, it is therefore desirable to have novel devices that would have better sound absorption as well as good exhaust purification, is simple to make and easy to fabricate, and is durable by being resistant to high temperature, corrosion, and impact from the flow of the exhaust.

Summary of Invention

An object of this invention is to provide a muffler that is effective in sound absorption over a wide spectrum of frequencies.

Another object of this invention is to provide a catalytic converter that is efficient in the removal of environmental contaminants from the exhaust.

Still another object of this invention is to provide a muffler and catalytic converter device that is effective in sound absorption over a wide spectrum of frequencies and efficient in the removal of environmental contaminants from the exhaust.

Yet still another object of this invention is to provide a muffler, a catalytic converter, or a muffler and catalytic converter having properties including simplicity in construction, easy and cheap to fabricate, durable and having a long useable lifespan resulting from its resistance to high temperature, corrosion, and impact from the flow of exhaust.

The present invention relates to the use of baffles of porous metal with large specific surface area as the sound absorption material and as the substrate for the catalyst in the catalytic converter. The large specific surface area of the porous metal enables effective sound absorption and provides a large area for the catalyst to be adsorbed resulting in efficient exhaust purification. By using the same type of material for the sound absorption and exhaust purification, it is possible not only to construct separate muffler and catalytic converter devices but also to combine these two devices into one.

The advantages of the devices of this invention are that they are effective in sound absorption over a wide spectrum of frequencies, efficient in the removal of environmental contaminants from the exhaust, simple to construct and fabricate for industrial production, durable, and has a long useable life as they are resistant to high temperature, corrosion, and impact from the flow of the exhaust.

Description of Drawings

The foregoing and other objects, aspects and advantages of the invention will be better understood from the following detailed description of preferred embodiments of this invention when taken in conjunction with the accompanying drawings in which:

Figure 1 is a diagram of a cross section of an embodiment of the muffler and catalytic converter device of this invention.

Figure 2 is a graph of the catalytic conversion rate as a function of the pore diameters for the different embodiments of this invention that uses metal substrates fabricated with porous metals and coated with catalysts.

Figure 3 is a structural diagram of an embodiment of this invention that uses porous metal as the sound absorption material and as the substrate for the catalyst coating.

Figure 4 is a structural diagram of an embodiment of this invention that uses porous metal as a sound absorption material and as the substrate for the catalyst coating.

Figure 5 is a structural diagram of the embodiment in Figure 4 as viewed from the direction of "A" as shown in Figure 4.

Figure 6 is a structural diagram an embodiment of the muffler and catalytic converter device of this invention.

Figure 7 is another structural diagram an embodiment of the muffler and catalytic converter device of this invention.

Figure 8 is still another structural diagram an embodiment of the muffler and catalytic converter device of this invention.

Detailed Description of the Preferred Embodiments

This invention provides in several embodiments a muffler and catalytic converter device, a muffler, and a catalytic to absorb, muffle or reduce noise and to purify the exhaust by the removal of environmental contaminants from the exhaust of an engine. Baffles of sound absorption material, which can also act as the substrate for the catalyst coating, are used. These baffles can be made from porous metal with predetermined pore diameter and pore density to achieve desired results for the conversion of exhaust contaminants and for sound absorption.

As shown in Figure 1, an embodiment of this invention comprises of a metal outer shell (2), with its two openings at the ends, the intake opening and the outtake opening, respectively connected with the intake pipe (1) and the outtake pipe (4). Baffles, i.e., sections of material(s), are placed inside the outer shell. These baffles have one or two functions. They can act as the sound absorption medium and they can also be the substrate for the deposition of a catalyst coating for purifying exhaust. Baffles can be made from porous metal have multiple pores having a predetermined pore density and pore diameter. (The pore density in one calculation method is the ratio of the volume of the pores with the volume of the total material * 100.) The baffles can be made from different materials to achieve the best results for sound absorption and exhaust purification. At least a part of a baffle is made from porous metal with pore diameters between 50μm and 1200μm and pore density between 80% and 98%. The preferred pore density is between 95% and 98% and the preferred pore diameter is between 400μm and 800μm. A coating of catalyst (6) can be attached to the surface of the porous metal material (3). A cushioning layer (5) can also be inserted between the porous metal (3) and the body of the outer shell (2). For better performance of the muffler

catalytic converter device, it is preferable that the volume of the device, i.e., the volume of the outer shell containing the baffles, is 0.3 to 7 times the volume of the displacement of the engine.

Electroplating is used to fabricate the porous metal with pores diameters between 50 to 1200 micrometers and pore density between 80% and 98%. High temperature oxidation, electrochemical anodic oxidation, etching with heated organic acid, or other methods are used to form a thin dense oxide layer on the surface of the substrate. This not only increases the adhesion between the substrate and the catalyst coating including the oxide layer such as aluminum oxide, zirconium oxide and cerium oxide, but also increases the substrate's ability to resist high temperature oxidation and increases the catalyst's purification efficiency and lifespan.

In embodiments of this invention, baffles of porous metal can be placed in sections across the direction of the exhaust flow, i.e., the flow from the intake opening to the outtake opening, with gaps between the baffles. A baffle can be typically placed across the direction of exhaust flow when the planes tangential to its surfaces (that are not touching the inside surfaces of the outer shell) forms an angle between $\pi/4$ radians and $\pi/2$ radians with the direction of exhaust flow. Figure 3 shows disc shaped baffles inside a cylindrical outer shell. In practice, the shape of the outer shell, as well as the shape of the baffles can vary. Also, multiple baffles can be placed inside the outer shell with gaps between the neighboring baffles and between the baffle and the inner surfaces of the shell. For example, an embodiment can be constructed where there are between three to six baffles forming four to seven gaps. Figure 7 shows an embodiment with six baffles and seven gaps.

The thickness of a baffle can be measured as the average distance between the planes tangential to the surfaces of the baffles that are not touching the surface of the outer shell. The thickness of a gap between two neighboring baffles can be measured as the average distance between neighboring planes tangential to the surfaces of the neighboring baffles that are not touching the surface of the gaps. The thickness of a gap between an inner surface of the outer shell and its neighboring baffle can be the average distance between the plane tangential to the surface of the baffle not touching the outer shell and the outer shell. For baffles of variable shapes, it is understood that the thickness of the baffles and the thickness of the gaps can vary but that they all fall within a pre-determined thickness. For the disc shaped baffles in Figure 3 that is inside a cylindrical shell, the thickness of the disc is the thickness of the baffle while the thickness of the gap between two baffles that are similarly placed would be the distance between the two neighboring disc surfaces of the baffles. The thickness of the gap between a baffle and the outer surface would be the distance between the inner flat surface of the outer shall and the neighboring flat surface of the disc. For embodiments where baffles are placed across the direction of exhaust flow, the preferred thickness of the baffles of porous metal is between 10mm and 100mm and the preferred thickness of the gaps is between 10mm and 150mm. Since embodiments of this invention use a porous metal with a high pore density (between 80% to 98%), a large pore diameter (between 50μm and 1200μm), and a high mechanical strength, exhaust can flow smoothly through this device without adding any additional air channels. This allows the porous metal to achieve the desired results with the embodiments described above.

In embodiments where two baffles are placed perpendicular to the flow of exhaust, a preferred ratio of the three gaps are: 1: between 1 and 10: between 1 and 2.

In another embodiment of this invention, the baffles of porous metal can also be placed either in single or multiple layers in the direction along the direction of the flow of the exhaust, leaving gaps between the layers of porous metal, and between the inside of the outer shell and the layers of porous material. A baffle is placed along the direction of exhaust flow when the planes tangential to its surfaces that are not touching the inside surfaces of the outer shell forms an angle between 0 radians and $\pi/4$ radians with the direction of exhaust flow. The baffles can be positioned as shown in Figure 4 and Figure 5, along the direction of the airflow with gaps between the baffles of porous metal (3), and the outer shell (2) and the porous metal (3). This configuration for the baffles of porous metal further lowers the exhaust pressure but slightly reduces the sound absorption. One or more baffles of sound absorption materials, including porous metal, with gaps between the baffles using above-described best thickness and gap size can be used in this configuration. The thickness of said baffles of porous metal is between 10mm and 100mm and the thickness of gap or gaps is between 5mm to 20mm.

In yet another embodiment spiral shaped baffles of porous metal can be placed inside an outer shell. An example of this embodiment is shown in Figure 8 where said baffles of porous metal (3) is placed inside a cylindrical outer shell (2) and a cushioning layer (5) parallel to the direction of the flow of the exhaust, the baffle of porous metal can be rolled such that a cross section of the baffle perpendicular to the flow of the exhaust is spiral shaped. In this embodiment, the thickness of the porous material is between 1mm and 5mm.

In some embodiments of this inventions that are mufflers, catalytic converters, or muffler and catalytic converter devices, said porous metal, a metal or an alloy, is one or more metals selected from the following group: nickel, iron, or titanium.

In other embodiments of this invention that are mufflers, catalytic converters, or muffler and catalytic converter devices, said porous metal is an alloy with two components, A and B, where component A is between 55 wt% and 95% wt.% of the porous metal and is one or more of the following: nickel, iron, or titanium. The B component is between 5wt.% and 45 wt.% of the porous metal and is one or more of the following: chromium, Cr, aluminum, Al, cobalt, Co, molybdenum, Mo, and zinc, Zn.

For some embodiments that are mufflers, said porous metal is a metal alloy containing two components, A and B, where said A component is between 55 wt% to 95 wt% of said porous metal and is one or more of the following: nickel, iron, and titanium and said B component is between 5wt.% to 45 wt.% of the porous metal and is one or more of the following: chromium, Cr, aluminum, Al, cobalt, Co, molybdenum, Mo, zinc, Zn, zirconium, Zr, vanadium, V, cerium, Ce, lanthanum, La, and Neodymium, Nd.

For embodiments that are catalytic converters or muffler and catalytic converter devices, the composition of the catalyst coating includes an active ingredient, an assisting ingredient, and a stabilizer. The active ingredient is one ore more rare earth metals from the following: cerium, Ce, lanthanum, La, praseodymium, Pr, and neodymium, Nd and small quantities of one or more precious metals from the following: palladium, Pd or Pa, platinum, Pt, rhodium, Rh, and ruthenium, Ru. The assisting ingredient is one or more of the following: manganese, Mn, calcium, Ca, barium, Ba, magnesium, Mg, zinc, Zn, and aluminum, Al. The stabilizer is one or more of the following: zirconium, Zr, potassium, K, sodium, Na, and lithium, Li.

The effectiveness of the sound absorption and exhaust purification of the embodiments is highly dependent on the properties of the porous metal, namely, the pore diameter and the

pore density. Examination of the sound absorption and exhaust purification results of different embodiments leads to the following conclusions.

The effectiveness of the exhaust purification is highly dependent on the size of the pore diameter of the porous metal. When the pore diameter is between 50μm and 1200μm, the purification results are good. The purification results are the best when the pore diameter is between 400μm and 800μm.

The sound absorption ability is also highly dependent on the size of the pore diameter. Seven groups of experiments were conducted in order to determine the preferred parameters for the pore diameter. The results are shown in Table 1.

Table 1

Group	Pore Diamter (μm)	coefficient of sound absorption for different frequencies				
		100 Hz	500 Hz	1500 Hz	2500 Hz	4000 Hz
1	50	0.14	0.24	0.32	0.28	0.26
2	100	0.22	0.37	0.45	0.42	0.36
3	200	0.28	0.54	0.68	0.72	0.73
4	400	0.35	0.62	0.75	0.72	0.74
5	800	0.35	0.68	0.71	0.72	0.75
6	1200	0.32	0.61	0.72	0.72	0.65
7	1600	0.26	0.41	0.52	0.62	0.55

Table 1 shows that the sound absorption coefficient of the device increases as the pore diameter increases exhibiting a trend to first increase from low to high and then decrease from high to low. The best results for sound absorption are obtained between 200μm to 1200μm. At the same time, the sound absorption results are better at high frequencies than low frequencies.

To achieve better sound absorption characteristics, especially at lower frequencies, methods such as leaving gaps between baffles of the sound absorption material and

reasonably increasing the thickness of the material are used. Theoretically, gaps can also have the effect of increasing the material's thickness. This is equivalent to increasing the effective length of the capillaries. This method will decrease the use of materials, lower cost, and improve the material's sound absorption properties, especially at the lower frequencies. To improve the sound absorption, gaps are also left between the sound absorption material (3) and the outer shell of the device (2) with a predetermined ratio between the gaps. Research shows that, especially at lower frequencies, sound absorption increases when the thickness of the porous material is between 10mm and 100 mm, and the size of the gap is between 10 mm and 150 mm. Therefore, embodiments of this invention have good sound absorption in a wide spectrum of frequencies. In another embodiment of this invention, when the three air gaps between two adjacent baffles of porous metal are in the ratio of 1:1~10:1~2, the sound absorption effects are the best and the purification results are not affected.

The pore density of the porous metal material significantly determines the specific surface area of the substrate that the catalyst is attached to, the purification and sound absorption characteristics, and the air resistance. Generally speaking, large pore density has the advantage of decreasing air resistance and increasing the sound absorption. However, if the pore density of the material is increased to above 98%, the technology of fabricating the porous metal is more difficult and uneconomical. Too high a pore density would also affect the mechanical strength of the porous metal by lowering its ability to resist impact from the exhaust. Therefore, the preferred specification is to limit the pore density of the porous material to be between 80% and 90%.

The pore density of the different baffles of sound absorption material gap can vary. In addition, the size of the gap between the sections can vary. The sound absorption can be

increased in a wider spectrum of frequencies by adjusting the pore density of the different sections and the thickness of the different gaps.

Embodiment 1

To fabricate the muffler and catalytic converter device of this embodiment, electroplating is used to first fabricate the baffles of porous nickel chromium alloy. Then the catalyst coating is fabricated on the porous metal alloy. The baffles of porous metal with catalyst coating are then inserted into a metal outer shell with a cushioning layer to form the final device.

(1) Fabrication and pre-treatment of the porous nickel chromium metal alloy:

In this embodiment, electroplating is used to fabricate the porous nickel chromium alloy to a thickness of 1.5mm to 3.0 mm, a pore density of between 95% and 98%, and a pore diameter of 400 μm. This porous metal alloy has good mechanical strength and flexibility. There are no sealed pores and the pore diameter is distributed evenly. The specifications and the formula metal plating to fabricate the nickel chromium alloy are shown in Table 2.

Table 2

Specifications	(g/L)
chromium chloride	50～80
nickel chloride	20～75
formic acid(mL/L)	10～95
boric acid	20～50
sodium citrate	25~100
ammonia chloride	30～120
sodium bromide	40～90
pH level	1～4
Temperature℃)	20～60
current density (A/dm2)	2～10
plating time (hour)	1～6

The ingredients listed in Table 2 are stirred to completely dissolve in de-ionized water to form the electrolyte. The pH is then adjusted to approximately 3.5. To improve the quality of the plating layer, an additive such as sodium dedocyl sulphonate or coumarin is added.

An inert graphite is used for the positive electrode while the negative electrode is a commercially available porous sponge-like material coated with a conducting agent with predetermined pore diameter and pore density. The plated porous metal obtained with this process contains 60% to 90% nickel and 10-40% chromium.

After said porous nickel chromium alloy is fabricated as described above, it is pretreated by etching with heat in organic acid for 1 to 5 hours before it is ready to be used as a substrate for the catalyst in the muffler and catalytic converter device. The etching with heat in organic acid forms a thin, dense layer of oxidized material on the surface of the porous nickel chromium alloy. Other methods such as high temperature oxidation or electrochemical anodic oxidation can also be used to form this oxide layer.

(2) Fabrication of the catalyst coating

The composition of the catalyst coating includes an active ingredient, an assisting ingredient, and a stabilizer. The active ingredient is at least one rare earth metals selected from the following group: cerium, Ce, lanthanum, La, praseodymium, Pr, and neodymium, Nd and small quantities of at least one precious metal selected from the following group: palladium, Pd (?Pa), platinum, Pt, rhodium, Rh, and ruthenium, Ru. The assistant? Ingredient is at least one of the following: magnesium, Mn, manganese, calcium, Ca, barium, Ba, magnesium, Mg, zinc, Zn, and aluminum, Al. The stabilizer is at least one of the following: zirconium, Zr, potassium, K, sodium, Na, and lithium, Li.

The catalyst coating of this embodiment contains a mixture of nanometer γ alumina and nanometer zirconia in the ratio of between 0:3 and 3:0. To fabricate the catalyst coating, a pre-determined ratio of a slurry mixture of powdered oxides of aluminum and zirconium is immersed in a saturated solution of cerium salt at a temperature of 30°C to 80°C for about to 2 hours to 5 hours to form a slurry. At that temperature, the porous metal substrate that has been etched with heat in organic acid is immersed in said slurry for 2 hours to 4 hours. Then, pressurized air or centrifuge is used to remove excess slurry from the substrate. The porous metal substrate is heated at 400°C to 600°C for 1 to 8 hours and then cooled to room temperature.

After cooling, the porous metal alloy substrate that has been calcined is heat treated in organic acid, then immersed in a solution containing soluble cerium salt, rhodium salt and small amounts of manganese salt at a temperature of between 30°C and 80°C for 2 hours to 4 hours. The calcinations process described above is then repeated to obtain the catalyst coating on the substrate for the muffler and catalytic converter device.

As illustrated in Figure 1, the muffler catalytic converter device of this embodiment made by placing the baffles of porous metal alloy (3) with catalyst coating (6) inside a cylindrical shaped stainless steel outer shell (2), and a cushioning layer (5).

Embodiment 2

The fabrication of the porous nickel chromium metal alloy and the pretreatment of the porous metal alloy remains the same as Embodiment 1.

To fabricate the catalyst coating layer, the porous nickel chromium metal alloy substrate that has been pretreated in organic acid to form an oxide layer is immersed in a

solution that include a pre-determined ratio of a mixture of soluble aluminum salt, zirconium salt, cerium salt, rhodium salt. After immersion, excess solution is removed and the substrate coated with said mixture is heat dried. The porous metal alloy with catalyst coating is heated at 400°C to 600°C for 2 hours to 6 hours and then cooled to room temperature. The above described processes, etching with organic acid, immersion, heat dry, and calcinations are repeated to form multi-layers of oxidized material on the surface of the substrate until the porous metal alloy with catalyst coating reaches the pre-determined technical specification.

As illustrated in Figure 1, the muffler catalytic converter device of this embodiment made by placing the porous metal alloy (3) with catalyst coating (6) inside a cylindrical shaped stainless steel outer shell (2), and a cushioning layer (5).

Embodiment 3

Nickel chromium metal alloy with a thickness of 1.5mm to 3.0 mm, a pore density of 95% to 98%, and a pore diameter of 50 μm is used as the substrate for the catalyst coating in this embodiment. Other than this, the fabrication of the muffler and catalytic device remains the same as Embodiment 1.

Embodiment 4

Nickel chromium metal alloy with a thickness of 1.5mm to 3.0 mm, a pore density of 95% to 98%, and a pore diameter of 200μm is used as the substrate for the catalyst coating in this embodiment. Other than this, the fabrication of the muffler and catalytic device remains the same as Embodiment 1.

Embodiment 5

Nickel chromium metal alloy with a thickness of 1.5mm to 3.0 mm, a pore density of 95% to 98%, and a pore diameter of 600μm is used as the substrate for the catalyst coating in this embodiment. Other than this, the fabrication of the muffler and catalytic device remains the same as Embodiment 1.

Embodiment 6

Nickel chromium metal alloy with a thickness of 1.5mm to 3.0 mm, a pore density of 95% to 98%, and a pore diameter of 800μm is used as the substrate for the catalyst coating in this embodiment. Other than this, the fabrication of the muffler and catalytic device remains the same as Embodiment 1.

Embodiment 7

Nickel chromium metal alloy with a thickness of 1.5mm to 3.0 mm, a pore density of 95% to 98%, and a pore diameter of 1000μm is used as the substrate for the catalyst coating in this embodiment. Other than this, the fabrication of the muffler and catalytic device remains the same as Embodiment 1.

Embodiment 8

Nickel chromium metal alloy with a thickness of 1.5mm to 3.0 mm, a pore density of 95% to 98%, and a pore diameter of 1200μm is used as the substrate for the catalyst coating in this embodiment. Other than this, the fabrication of the muffler and catalytic device remains the same as Embodiment 1.

The above-described embodiments were placed in automobiles and their conversion rates of exhaust contaminants were measured. Their conversion rates for CO, HC, NOx after test driving for 30,000 km are listed in the Table 3.

Table 3

Pore Diameters and Conversion Rates

	Embodiment 1	Embodiment 2	Embodiment 3	Embodiment 4	Embodiment 5	Embodiment 6	Embodiment 7	Embodiment 8
Pore diameter (μm)	400	400	50	200	600	800	1000	1200
CO Conversion Rate (%)	91	94	80	83	95	93	87	75
HC Conversion Rate(□)	94	93	75	76	93	90	83	70
Nox Conversion Rate(□)	72	70	50	55	74	73	71	60

Figure 2 is the graph of pore diameter vs. conversion rates for Embodiments 2, 3, 4, 5, 6, 7, and 8. The figure shows that when porous nickel chromium is used for the substrate for the catalyst, the effectiveness of the catalytic converter part of this device is highly dependent on the pore diameter. The conversion rate of exhaust contaminants is good when the pore diameter is between 50μm and 1200 μm. The conversion rates are the best when pore diameter is between 400μm and 800μm with the CO and HC conversion rates above 90% and the NOx rates above 70%.

Embodiment 9

In this embodiment, there are two baffles of sound absorbing material made from porous nickel fabricated by electroplating that are secured in two sections to the inside of the outer metal shell and placed perpendicular to the direction of the exhaust flow. Gaps are left between the porous metal and the outer shell and between the different sections of the baffles of porous metal. The pore density is between 80% and 98%. Best sound absorption results are obtained when the pore density is between 95% and 98%. The pore diameter of the porous metal is 200μm. The thickness of the porous metal is between 10mm and 100mm and the thickness of the gaps is between 10mm and 150 mm. The porous nickel fabricated by electroplating has evenly spaced pores, with no sealed pores. Therefore, this material has high structural strength and pre-determined flexibility.

Embodiment 10

In this embodiment, the pore diameter of the porous nickel is 400μm. All other specifications are the same as Embodiment 9.

Embodiment 11

In this embodiment, the pore diameter of the porous nickel is 800μm. All other specifications are the same as Embodiment 9.

Embodiment 12

In this embodiment, the pore diameter of the porous nickel is 1200μm. All other specifications are the same as Embodiment 9.

Embodiment 13

In this embodiment, the porous nickel chromium alloy containing 55 wt.% of nickel and 45 wt.% of chromium has a pore diameter of 200μm. All other specifications remain the same. This embodiment is more durable and has a longer useable life since the porous nickel chromium is strong with a high resistance to oxidation and heat corrosion.

Embodiment 14

In this embodiment, the porous nickel chromium alloy containing 75 wt.% of nickel and 25 wt.% of chromium has a pore diameter of 200μm. All other specifications remain the same.

Embodiment 15

In this embodiment, the porous nickel chromium alloy containing 95 wt.% of nickel and 5 wt.% of chromium has a pore diameter of 200μm. All other specifications remain the same.

Embodiments 9 through 15 were placed in automobiles and the their sound absorption properties were tested using the Automobile Standard Noise Measuring Method (GB/T 14365-93) and External Noise Limit and Testing Method for Automobile Acceleration (GB 1495-2002), the noise level were all lower than 76dB and 73dB, all lower than the national standards. In addition, the useable lives for embodiments of this invention using porous metal alloy are longer than those using a single metal element as the porous metal material.

Embodiment 16

Figure 3 illustrates this embodiment that includes an outer metal shell (2). The two ends of the outer shell (2) are separately connected with the intake pipe (1) and the outtake pipe (4). The intake and outtake pipes can be secured with flanges. The outer shell (2) holds baffles of porous metal (3) with pore density between 80% and 98% and pore diameter between 50μm and 1200μm. A coating of catalyst is attached to the surface of the porous metal. The baffles of porous metal are also sound absorbing material (3) and are placed perpendicular to the direction of the exhaust flow inside outer shell (2). (Figure 3 shows two baffles. In practice, multiple baffles can be used.) Gaps are left between the baffles of sound absorption material. The thickness of the baffles is between 10mm and 100mm. The thickness of the gaps is between 10mm and 150mm. For embodiments having two baffles of porous material, the ratio of the thickness of the three gaps is 1:5:2.

Said porous metal material, a metal or an alloy, is at least one of the metals selected from the following group: nickel, iron, or titanium. In the alternative, the porous metal can also be composed on an alloy with two components, A and B, where the A component is 55 wt.% to 95% wt.% of the porous metal and is at least one of the following: nickel, iron, or titanium. The B component is 5wt.% to 45 wt.% of the porous metal and is at least one of the following: chromium, Cr, aluminum, Al, cobalt, Co, molybdenum, Mo, and zinc, Zn.

The composition of the catalyst coating includes an active ingredient, an assisting ingredient, and a stabilizer. The active ingredient is at least one rare earth metals selected from the following group: cerium, Ce, lanthanum, La, praseodymium, Pr, and neodymium, Nd and small quantities of at least one precious metal selected from the following group: palladium, Pd or Pa, platinum, Pt, rhodium, Rh, and ruthenium, Ru. The assistant ingredient

is at least one element selected from the following: manganese, Mn, calcium, Ca, barium, Ba, magnesium, Mg, zinc, Zn, and aluminum, Al. The stabilizer is at least one element selected from the following: zirconium, Zr, potassium, K, sodium, Na, and lithium, Li.

Embodiment 17

Referring Figures 4 and 5, in this embodiment, the baffles of porous metal forming the substrate for the catalyst coating and for sound absorption are placed parallel to the direction of exhaust flow. Although the figures show only one baffle, more than one can be placed such that, in a cross-sectional view such as Figure 3, the baffles form concentric rings. Gaps are formed between neighboring baffles and between the baffle and the surface of the metal outer shell (2) that forms channels for the exhaust to flow directly through this device. This configuration reduces the exhaust pressure. However, sound absorption is also lowered than the device shown in embodiment 16. The best specification for the thickness of the baffles of porous metal is between 10mm and 100mm, and the thickness of the gaps is between 5mm and 20mm.

Embodiment 18

As shown in Figure 6, the front (left) baffle inside the outer metal shell (2) is the sound absorption material made from porous metal (3) while the back (right) baffle (7) is the housing for the catalyst coating made of corrugated metal. All other specifications remain the same as Embodiment 16.

Embodiment 19

As Figure 7 shows, this embodiment places baffles of porous metal (3) between baffles of corrugated metal coated with catalyst (7). There are gaps between the baffles. All other specifications remain the same as Embodiment 16.

Embodiment 20

As Figure 3 shows, in this embodiment, there are two baffles of porous metal in the outer shell. The volume of the catalytic converter muffler device in this embodiment is 5 times the displacement of the engine producing the exhaust. All other specifications are the same as Embodiment 16.

Embodiment 21

As Figure 3 shows, in this embodiment, there are two baffles of porous metal in the outer shell. The volume of the catalytic converter muffler device in this embodiment is 0.3 times the displacement of the engine producing the exhaust. All other specifications are the same as Embodiment 16.

Embodiments 16 through 21 are placed inside common sedans. When tested according to government standards (GB/T3845-93) during vehicle operation, the purification efficiency are all over 95% for HC, CO, and Nox. When tested according to European Exhaust Testing Standards #11, for Embodiments 16 through 21, their CO exhaust volume is less than 1.9g/km, total exhaust volume for HC and Nox is less than 0.4g/km.

The sound absorption properties of the embodiments of this invention are excellent and no additional mufflers are needed to achieve sound absorption. When the insertion loss

reaches 20 to 30 dB, less than 5% of the engine efficiency is lost and the exhaust backpressure is less than 15Kpa.

While the present invention has been described with reference to certain preferred embodiments, it is to be understood that the present invention is not limited to such specific embodiments. Rather, it is the inventor's contention that the invention be understood and construed in its broadest meaning as reflected by the following claims. Thus, these claims are to be understood as incorporating not only the preferred embodiments described herein but all those other and further alterations and modifications as would be apparent to those of ordinary skilled in the art.

We Claim: